Repaired Reinforced Concrete Walls and Lower-Damage Modifications

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Introduction:

As a result of the Canterbury earthquakes, over 60% of the concrete buildings in the Christchurch Central Business District have been demolished. This experience has highlighted the need to provide guidance on the residual capacity and repairability of earthquake-damaged concrete buildings. Experience from 2010 Chile indicates that it is possible to repair severely damaged concrete elements (see photo at right), although limited testing has been performed on such repaired components. The first phase of this project is focused on the performance of two lightly-reinforced concrete walls that are being repaired and re-tested after damage sustained during previous testing.

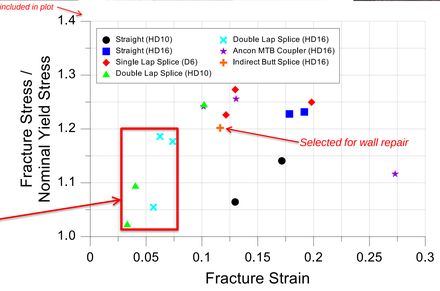
Wall repair, Chile 2010 (Sherstobitoff et al 2012)

Tensile Testing of Reinforcement Connections:

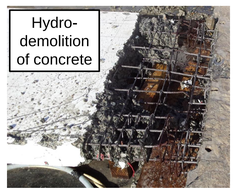
No.	Connection	Rebar	Drawing	Electrode	Weld position	Current	Pre/Post Heat
1.11 #1 1.11 #2	Straight Bar	HD10		None	None	None	None
1.12 #1 1.12 #2	Straight Bar	HD16		None	None	None	None
1.21 #1 1.21 #2 1.21 #3	Single lap splice	R6		AS/NZS 4855B-E4313-A			
1.31 #1 1.31 #2 1.31 #3	Double-lap splice	HD10		AS/NZS 4857B-E7618-GA H5 (P118)	Vertical	100A	Pre Heat ~100°C
1.32 #1 1.32 #2 1.32 #3	Double-lap splice	HD16		AS/NZS 4857B-E7618-GA H5 (P118)	Vertical	100A	Pre Heat ~100°C
1.42 #1 1.42 #2 1.42 #3	Double-V butt splice	HD16		AS/NZS 4857B-E7618-GA H5 (P118)	Horizontal	100A	Pre Heat ~100°C
1.61 #1 1.61 #2 1.61 #3	Ancon MBT coupler	HD16		None	None	None	None
1.71 #1 1.71 #2 1.71 #3	Indirect butt splice using two bars, welded both sides	HD16		AS/NZS 4857B-E7618-GA H5 (P118)	Vertical	100A	Pre Heat ~100°C

Note: Red text indicates recording of erroneous strain data; data points not included in plot

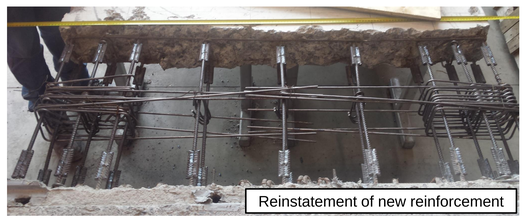
Failure did not occur at weld, except for lap splices



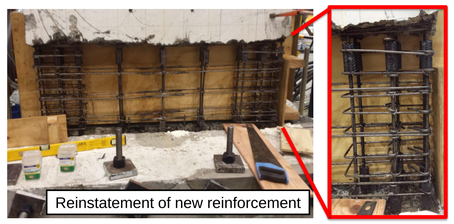
Repair of Wall R1:



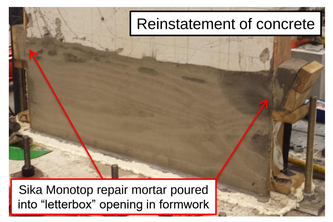
Removal of existing reinforcement



Reinstatement of new reinforcement



Reinstatement of new reinforcement



Repair of Wall R2 (ongoing):

Next steps:

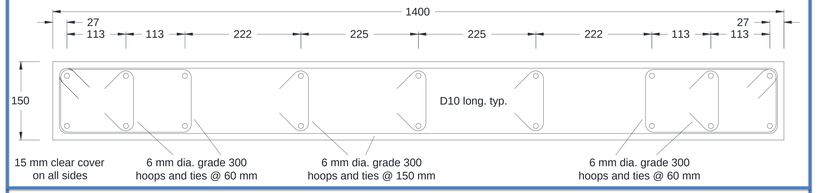
- Concrete reinstatement
- Crack injection

Cross-Section of Wall R1 and R2:

(same as original walls)

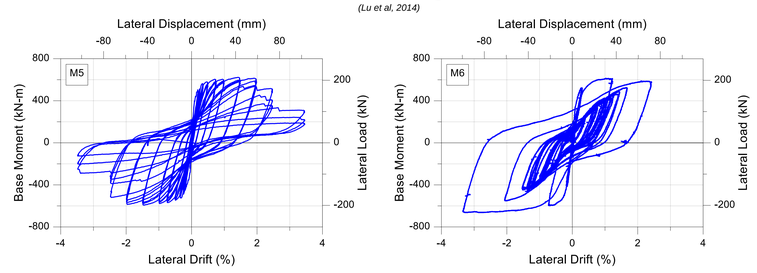
$\rho_{boundary} = 0.011$
$\rho_{web,vert.} = 0.005$

$A_c/A_g = 0.66$
$s/d_b = 6.0$

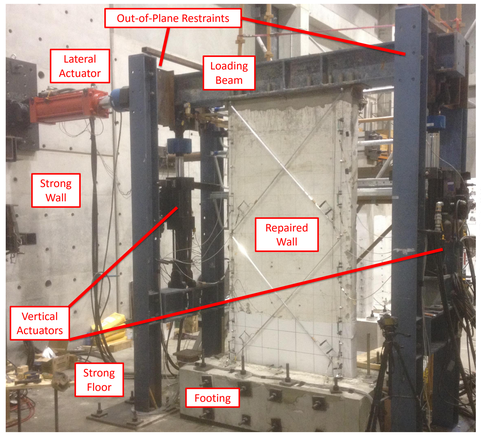


Performance of Original Walls:

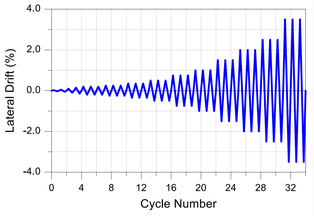
(Lu et al, 2014)



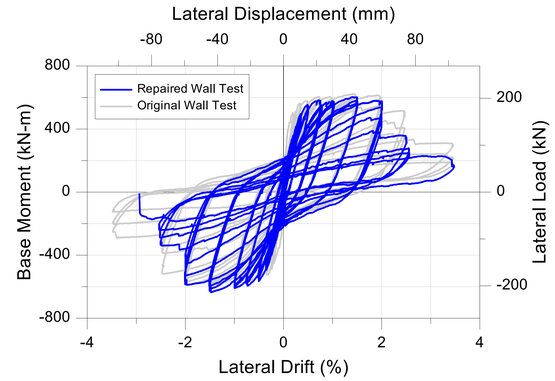
Test Setup:

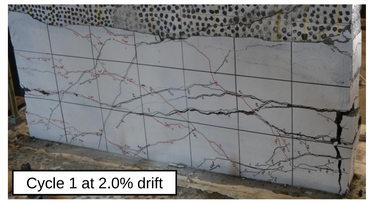


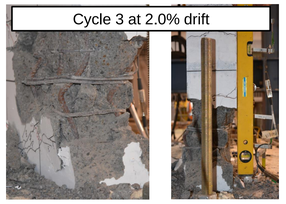
- Axial load = $0.035A_g f'_c$
- Shear span ratio (h/l_w) = 2.1
- Reversed-cyclic testing protocol same as original walls:



Test Results (Wall R1):



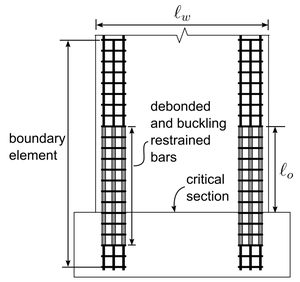




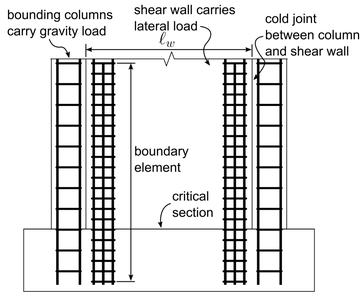
Ongoing/Future Study – Modelling of Lower-Damage Concepts:

Goal: Explore simple modifications of conventional designs to reduce damage and improve repairability after significant earthquakes.

Tension-controlled wall:
- ✓ Debond longitudinal bars around critical section to avoid strain concentration at crack
- ✓ Restrain bar buckling in debonded length



Compression-controlled wall:
- ✓ Locate columns adjacent to walls to reduce wall axial loads



Acknowledgements:

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